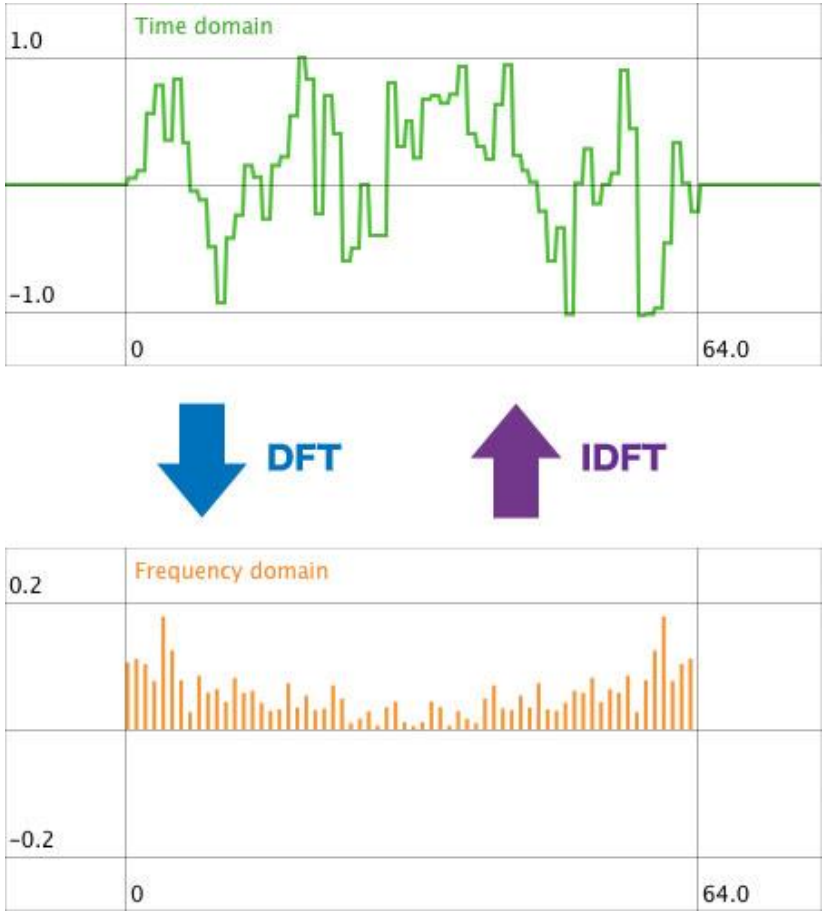
Discrete Fourier Transform(DFT)

- DFT applies Fourier transform to digitized data.
- The signal is transformed to time domain to frequency domain.
- IDFT is Inverse DFT.



DFT(1)

- Discrete Fourier Transform(DFT)
  - Time domain→Frequency domain

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-j\frac{2\pi}{N}kn}$$

- Inverse DFT (iDFT)
  - Frequency domain→Time domain

$$x(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(k) \mathrm{e}^{j\frac{2\pi}{N}kn}$$

DFT(2)

- Apply Euler's formula

$$e^{-j\frac{2\pi}{N}kn} = \cos\left(\frac{2\pi}{N}kn\right) - j\sin\left(\frac{2\pi}{N}kn\right)$$

- DFT

$$X(k) = \sum_{n=0}^{N-1} x(n)\left(\cos\left(\frac{2\pi}{N}kn\right) - j\sin\left(\frac{2\pi}{N}kn\right)\right)$$

- iDFT

$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} X(k)\left(\cos\left(\frac{2\pi}{N}kn\right) + j\sin\left(\frac{2\pi}{N}kn\right)\right)$$

DFT(3)

- Separation of real part and imaginary part

$$X_{re}(k) = \sum_{n=0}^{N-1}\left(x_{re}(n)\cos\left(\frac{2\pi}{N}kn\right) + x_{im}(n)\sin\left(\frac{2\pi}{N}kn\right)\right)$$

$$X_{im}(k) = j\sum_{n=0}^{N-1}\left(-x_{re}(n)\sin\left(\frac{2\pi}{N}kn\right) + x_{im}(n)\cos\left(\frac{2\pi}{N}kn\right)\right)$$

} DFT

$$x_{re}(n) = \frac{1}{N}\sum_{k=0}^{N-1}\left(X_{re}(k)\cos\left(\frac{2\pi}{N}kn\right) - X_{im}(k)\sin\left(\frac{2\pi}{N}kn\right)\right)$$

$$x_{im}(n) = j\frac{1}{N}\sum_{k=0}^{N-1}\left(X_{re}(k)\sin\left(\frac{2\pi}{N}kn\right) + X_{im}(k)\cos\left(\frac{2\pi}{N}kn\right)\right)$$

} iDFT

DFT(4)

```
for(i = 0; i < num; i++){
  for(j = 0; j < num; j++){
    temp_re[i] += re[j]*cos(2*PI*i*j/num + flag*im[j]*sim(2*PI*i*j/num);
    temp_im[i] += -flag*re[j]*sin(2*PI*i*j/num) + im[j]*cos(2*PI*i*j/num);
    // if DFT, flag = 1, else if iDFT, flag == -1
    }
  if(iDFT){
    temp_re[i] /= num;
    temp_im[i] /= num;
  }
}
for(i = 0; i < num; i++){
  re[i] = temp_re[i];
  im[i] = temp_im[i];
}
```

Contest Program

- $ ./dft -n 8 -s 3
- the number of elements : 1024
- the name of dataset : data_3.txt

Options…
-n [1-8] : the number of elements
-s [1-3] : select data set

- Elapsed time on CPU (DFT) : 167.144287 [msec]
- Elapsed time on CPU (IDFT) : 167.164734 [msec]

- Elapsed time on GPU (DFT) : 1.763616 [msec]
- Elapsed time on GPU (IDFT) : 1.693888 [msec]

Elapsed time & acceleration ratio

- 94.773628 times faster on dft!!
- 94.785225 times faster on idft!!

- Degree of similarity = 0.998622
- correct !!
- When this result is close to 1, the calculation is correcter

Verify the results…
Compute the similarity
similarity is 1 ～ -1

Contest

- Minimum Requirement
  - Accelerating DFT & IDFT by using GPU
    - Modify only gpu_calc.cu
    - Not have to execute all parts on GPU
    - Initialization and verification supported by toolkit
- Advanced
  - Optimization to achieve higher performance

Toolkit(Code)

- gpu_calc.cu
  - DFT & iDFT program for GPU
  - not implemented (please modify this file)
- cpu_calc.cpp
  - DFT & iDFT program for CPU
  - Refer to modify gpu_calc.cu
- main.cpp
  - Initialize & call functions

How to use toolkit

- make
  - Compile
- ./dft
  - run your program with default parameter
- ./dft –n [num] –s [num]
  - run your program with selected parameter
- ./dft –h
  - Help

Deadline

- 8/3 24:00
- Leave your design on your account
- Mail to kaneda@am.ics.keio.ac.jp with a simple report including:
  - Result of speed up
  - How did you try to improve the performance
- No submission, no unit.
- The contest results will be announced asap after the deadline.

Tips for parallel processing

- DFT is consisting of double loops.
- You should parallelize the outer loop first.
- For parallelize the inner loop, you should use reduction calculation well.